(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
25 October 2001 (25.10.2001)

PCT

(10) International Publication Number
WO 01/79690 A1

(51) International Patent Classification⁷: F02M 69/44, F02D 3/04, F02B 15/00

(21) International Application Number: PCT/SE01/00836

(22) International Filing Date: 17 April 2001 (17.04.2001)

(25) Filing Language: Swedish

(26) Publication Language: English

(30) Priority Data:
0001451-4 19 April 2000 (19.04.2000) SE

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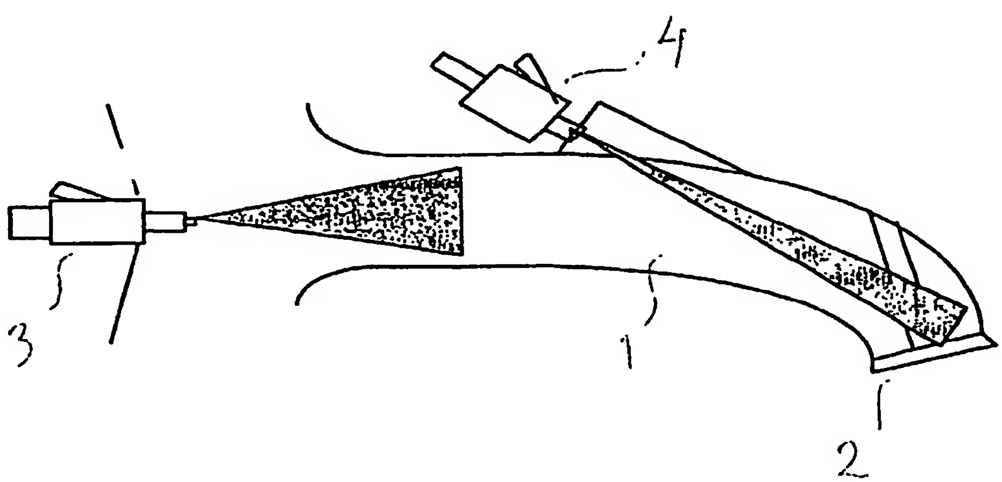
(81) Designated States (*national*): AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, TZ, UA, UG, US, UZ, VN, YU, ZA, ZW.

(84) Designated States (*regional*): ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE, TR), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).

Published:
— *with international search report*

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

(54) Title: A METHOD AND DEVICE FOR AN INTERNAL COMBUSTION ENGINE



(57) Abstract: The present invention concerns a device for fuel injection intended for an internal combustion engine with a wide range of speeds of revolution and with high requirements for rapid response such as, for example, the engine in a motor cycle, and a method of controlling fuel injection to such an engine. In the invention according to the present application the fuel injection to an internal combustion engine comprising an intake pipe (1) with at least one intake valve (2) and one or more injectors is controlled in such a manner that a first fuel injection in order to obtain a well prepared air/fuel mixture occurs early in the working cycle of the engine following the closure of the intake valve and a second fuel injection in order to obtain an optimal amount of fuel for the cycle, a process known as "transient compensation", occurs late in the working cycle before closure of the intake valve.

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Title: A Method and Device for an Internal Combustion Engine

Technical Area

The present invention concerns a device for fuel injection intended for an internal combustion engine with a wide range of speeds of revolution and with high requirements for rapid response such as, for example, the engine in a motorcycle, and a method of controlling fuel injection to such an engine.

The Prior Art

It is of the highest importance in internal combustion engines that the correct mixture of air and fuel is obtained at the correct instant in order to obtain maximal power and to achieve minimum emissions. Better control of the air/fuel mixture is obtained with the aid of fuel injection than is obtained in an engine with a carburettor. It is most common that injection occurs in the intake pipe prior to the combustion chamber. Two injectors are normally required in engines with a wide range of speeds of revolution in order to cope with the dynamic properties of the engine. The engines of motorcycles are examples of engines with advanced dynamic properties and high requirements for rapid response. The injectors have previously most often been applied in parallel and in this way received similar properties for the preparation of air/fuel. In cases where high requirements for rapid response are present, one disadvantage with existing solutions comprising double injectors working in parallel at a considerable distance from the combustion chamber is the surface film that forms when the fuel mixture is spread in the intake pipe, and the long transport time between the injection valve and the intake valve that the fuel mixture must travel. Existing solutions comprising double injectors working in parallel with a short distance to the combustion chamber have problems with poor fuel/air preparation due to the time and transport path being too short, and there are problems with the construction of these solutions.

The present invention concerns the provision of a solution that satisfies the high requirements for rapid and exact fuel supply that is required in motors with advanced dynamic properties.

Summary of the Invention

The present invention concerns a method for controlling fuel injection into an internal combustion engine with advanced dynamic properties and a device for fuel injection into an internal combustion engine.

In the invention according to the present application the fuel injection to an internal combustion engine comprising an intake pipe with at least one intake valve and one or more injectors is controlled in such a manner that a first fuel injection to obtain a well prepared air/fuel mixture occurs early in the working cycle of the engine following the closure of the intake valve and a second fuel injection to obtain an optimal amount of fuel for the cycle, a process known as "transient compensation", occurs late in the working cycle before closure of the intake valve.

In order to know exactly the instant at which transient compensation is to take place, a function of the speed of revolution is used whereby the timing can be estimated and transient compensation can occur as late as possible before closure of the intake valve for the most rapid response possible. Calculations of the required amount of fuel for both stationary conditions and for transient compensation are based on the dynamic properties of the surface film. The position of the throttle is also detected for the correct calculation of the amount of fuel for transient compensation. In this way, the possibility of being able to provide compensation with the correct amount of fuel at the correct instant immediately before the valve closes is obtained. In this way, control of the amount of fuel injected is achieved, and the fuel is provided exactly when it is needed. It is difficult using traditional technology to estimate the amount of fuel that actually entered the cylinder before the valve closed and how much remained for the next cycle.

Short Description of the Drawings

In the following text, reference will be made to the accompanying drawings for a better understanding of the described embodiments and examples of the present invention, in which:

Fig. 1 shows a sketch of a device according to the present invention;

Fig. 2 shows the fuel injection pulses as a function of time.

Detailed Description of Preferred Embodiments

Figure 1 shows an intake pipe 1 with an intake valve 2, a first injector 3 and a second injector 4. In one preferred embodiment, the first injection occurs from a first injector 3 and the second injection occurs from a second injector 4. The said injectors are arranged in the intake pipe 1 such that the first and the second injectors are displaced relative to each other in the direction of flow of the air flow, whereby the second injector is arranged close to the intake valve while the first injector is arranged considerably earlier in the direction of flow of the air. In this way, a difference concerning the transport time for the fuel mixture from each injector to the intake valve is achieved. In this embodiment, the first injector 3 is principally

used for the injection of an amount of fuel corresponding to stationary conditions, while the second injector 4 is principally used for compensation of fuel supply under transient conditions. The jet of fuel mixture from the second injector 4 in one preferred embodiment is aimed directly at the intake valve 2.

Figure 2 shows the fuel injection pulses from the first injector and from the second injector as functions of time. Stationary injection is shown in Figure 2a. A pulse 20 is a fuel injection from the first injector 3. The curve 24 shows how the intake valve opens and closes during the previous cycle. The pulse 20 lies immediately after the intake valve has closed during the previous cycle. Figure 2b shows transient injection. A pulse 21 is an injection of fuel from the second injector 4. The curve 23 shows how the intake valve opens and closes during the current working cycle while the curve 22 shows how the exhaust valve opens and closes. The pulse 21 lies late in the working cycle, immediately before the intake valve closes.

Compensation of the fuel supply during transient conditions is carried out simultaneously with rotation of the crank angle of the engine. In order to optimise the amount of fuel for the current cycle, compensation occurs at that crank angle that is the latest crank angle possible in order for the injected fuel amount to have sufficient time to enter the cylinder before the intake valve 2 closes. This latest recent crank angle varies with the speed of revolution of the engine.

The device according to the present application comprises an intake pipe 1 with at least one intake valve 2 with a valve head and at least one injector. In one preferred embodiment a first injector 3 and a second injector 4 are arranged in the said intake pipe 1. The said first and second injectors are arranged displaced relative to each other with respect to the direction of flow of the air. The rapid dynamic properties of the motor are handled by combining these two injectors.

The second injector 4 is arranged close to the intake valve , while the first injector 3 is arranged considerably earlier in the direction of flow of the air. In this way, a difference in the transport time from the injection valve to the intake valve is achieved, and a difference in the target image for the fuel mixture from the different injectors. The second injector 4 is primarily designed for high loads and transient compensation. The location of the second injector and the simultaneous compensation of transients provide the possibility for a rapid and exact injection directly towards an open valve at high loads, which cools the mixture more and in this way gives a higher torque through a higher degree of filling of the combustion chamber. These two factors also give a lower sensitivity to knocking. A short transport time for the fuel mixture between the injection valve and the intake valve is

achieved by placing the second injector 4 as close as possible to the intake valve 2, which gives a rapid response when the load is increased. In one preferred embodiment, the first injector 3 can be of the type known as "single jet type" with a broad cone, while the second injector 4 can be of the type known as "multi-jet type" depending on the number of intake valves.

In one preferred embodiment, the second injector 4 is angled relative to the first, or the injectors can be arranged such that the jets of fuel are arranged at an angle, in such a manner that the jet of fuel mixture can be directly aimed at the valve head, giving a more rapid response for the engine.

The function and construction of the present invention is assumed to be made clear by the description given. Even if the embodiments that have been shown or described have been preferred, it is evident that modifications of these can be made within the framework of the scope that is defined in the accompanying claims.

CLAIMS

1. A method to control fuel injection in an internal combustion engine, whereby at least one intake pipe (1) with at least one intake valve (2) and at least two injectors (3, 4) are included, whereby a first injection of fuel in order to obtain a well prepared fuel/air mixture occurs early in the working cycle of the engine following closure of the intake valve (2) and a second injection of fuel in order to obtain the optimal amount of fuel occurs late in the working cycle before closure of the intake valve (2), c h a r a c t e r i s e d in

- that the first fuel injection occurs from a first injector (3) in the said intake pipe (1), which is arranged significantly earlier in the flow of direction of air than a second injector (4), whereby the first injection of fuel is principally used for injection along the direction of flow of the air towards the intake valve (2) of the amount of the said fuel that corresponds to stationary conditions, and
- that the second injection of fuel occurs from a second injector (4), which is arranged close to the intake valve (2) in the said intake pipe (1) and the fuel mixture jet of which is injected directly towards the open intake valve (2), whereby the second injection of fuel is principally used for compensation of the supply of the said fuel during transient conditions, whereby a difference concerning the transport time for fuel from the relevant injector (3, 4) to the intake valve (2) is achieved.

2. The method according to claim 1, c h a r a c t e r i s e d in that compensation of fuel supply during transient conditions is carried out simultaneously with rotation of the crank angle, in such a manner that injection occurs at a crank angle, that depends on the speed of revolution of the engine, preferably the latest crank angle, where the injected amount of fuel can be included in the cylinder.

3. The method according to claim 2, c h a r a c t e r i s e d in that calculation of the amount of fuel for transient compensation is based on the detection of the position of the throttle.

4. The method according to claim 1, c h a r a c t e r i s e d in that calculation of the amount of fuel required for transient compensation and/or for stationary conditions is based on the dynamic properties of the surface film.

5. A device to control fuel injection in an internal combustion engine, whereby at least one intake pipe (1) with at least one intake valve (2) with a valve head and at least two injectors (3, 4) are included, whereby it is arranged to obtain a well prepared fuel/air mixture early in the working cycle of the engine following closure of the intake valve (2) by means of a first injection of fuel and it is arranged to obtain an amount of the said fuel for the current working cycle late in the working cycle before closure of the intake valve (2) by means of a second injection of fuel, characterised in that
- the first fuel injection is arranged to occur along the direction of flow of the air towards the intake valve (2) from a first injector (3) in the intake pipe (1), which first injector (3) is arranged significantly earlier in the flow of direction of air than a second injector (4), whereby the first injection of fuel is intended to correspond to stationary conditions, and that
- the second injection of fuel is arranged to occur from the second injector (4), which is arranged close to the intake valve (2) in the said intake pipe (1) and the fuel mixture jet of which is aimed directly towards the open intake valve (2), whereby the second injection of fuel is principally intended for the compensation of the supply of fuel during transient conditions, whereby a difference concerning the transport time for fuel from the relevant injector (3, 4) to the intake valve (2) is achieved.

6. The device according to claim 5, characterised in that the injectors (3, 4) are arranged such that the fuel jets are placed at an angle relative to each other.

7. The device according to any one of claims 5-6, characterised in that the second injector (4) is of the type known as a "multi-jet type".

8. The device according to any one of claims 5-7, characterised in that the first injector (3) is of the type known as a "single jet type" with a broad cone.

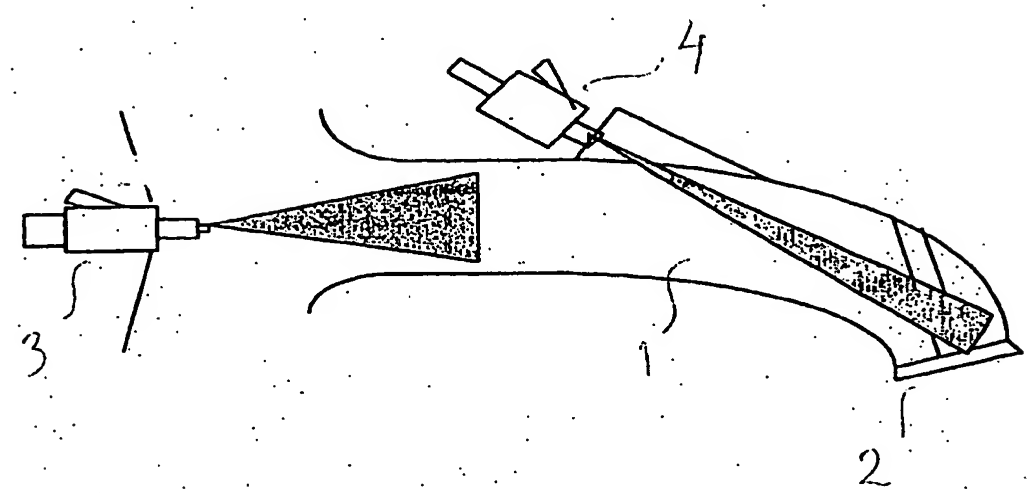

Fig. 1

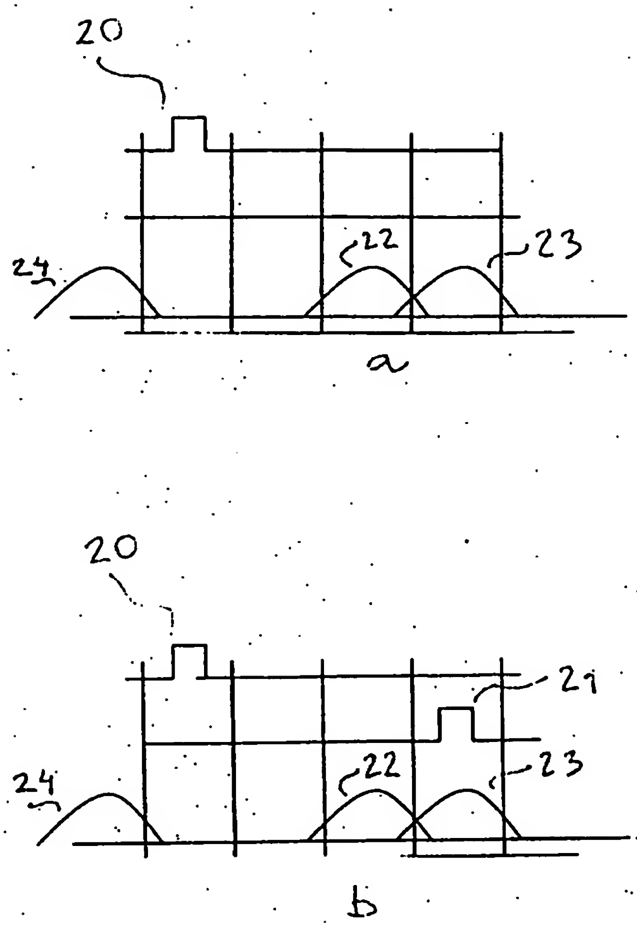

Fig. 2

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE 01/00836

A. CLASSIFICATION OF SUBJECT MATTER

IPC7: F02M 69/44, F02D 3/04, F02B 15/00
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC7: F02M, F02D, F02B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 5297531 A (AKASE), 29 March 1994 (29.03.94), abstract --	
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A	US 4096839 A (NIERTIT), 27 June 1978 (27.06.78), abstract --	
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[X] Further documents are listed in the continuation of Box C. [X] See patent family annex.

* Special categories of cited documents:
- "A" document defining the general state of the art which is not considered to be of particular relevance
- "E" earlier application or patent but published on or after the international filing date
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- "&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
30 May 2001	19-06-2001
Name and mailing address of the ISA/ Swedish Patent Office Box 5055, S-102 42 STOCKHOLM Facsimile No. +46 8 666 02 86	Authorized officer Dan Ionesco / JA A Telephone No. +46 8 782 25 00

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE 01/00836

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

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30/04/01

International application No.
PCT/SE 01/00836

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